

AN APPROACH FOR HOTEL TYPE SELECTION BASED ON THE SINGLE-VALUED INTUITIONISTIC FUZZY NUMBERS

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ABSTRACT

The main objective of this paper is to emphasize the importance of the involving the Multiple-Criteria Decision-Making (MCDM) methods in the process of the selection of the optimal type of hotel for investment. Besides, the application of the Single-Valued Intuitionistic Fuzzy Numbers (SVIFN) is proposed. The applicability of the proposed approach is demonstrated through real case study directed to the selection of the appropriate type of hotel for investment that should be constructed in the Golija Mountain. Three decision-makers estimated five alternative types of hotels relative to the five evaluation criteria. The obtained results are reliable and representative and confirm that introducing of the appropriate multiple-criteria models minimize the possibility of making wrong decisions.

Keywords: Multiple-Criteria Decision-Making, Single-Valued Intuitionistic Fuzzy Numbers, Hotel property development, Investment, Selection

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INTRODUCTION

Investing in the development of a hotel is similar to investing in any kind of real estate and contains three main phases: development, operation and exit (Younes & Kett, 2006). The issue that further complicates decisions about investment in this kind of property is question if the investor should invest in a full service hotel, limited service hotel, and apartments or shared ownership. Development of the mentioned types of facilities is followed by different levels of risk and because of that all influential criteria should be appreciated during the decision-making and selection process. The authors proposed different sets of the criteria for the selection of optimal real estate i.e. hotel for investing in. Some of these authors are Zavadskas, Ustinovichius & Stasiulionis (2004), Migilinskas & Ustinovichius (2007), Ginevičius & Zubrecovas (2009). Because decision-making process is relied on the set of criteria that often are conflicting, the Multiple-Criteria Decision-Making (MCDM) methods are suitable for applying in the area of the selection of the suitable type of a hotel for investment.

The MCDM methods are widely used for the facilitation of the decision-making process in different business fields (Popovic *et al.*, 2019; Stojcic *et al.*, 2019; Chatterjee & Stevic, 2019; Nunic, 2018; Stanujkic & Karabasevic, 2018; Pamucar *et al.*, 2018; Milosavljevic, Bursaca & Trickovic, 2018; Veskovic *et al.*, 2018). The good overviews of these methods are given in the papers by Velasquez & Hester (2013), and Mardani *et al.* (2015a). During the time, appropriate extensions of the given methods are proposed by introducing the fuzzy sets and some authors performed the systematization of the extended methods (Mardani *et al.*, 2015b; Kahraman, Onar & Oztaysi, 2015).

In the area of the hotel operating, the MCDM methods are most often used for estimation of the building's energy efficiency (Xu & Chan, 2013), for the location selection (Krylovas, Zavadskas & Kosareva, 2016), and accomodation quality estimation (Park, Kim & Choo, 2014). The selection of the suitable type of hotel for construction is the topic that was not observed enough. The authors give the attention to the selection of the construction projects in general (Ebrahimnejad *et al.*, 2012; Taylan *et al.*, 2014; Gajzler & Zima, 2017). Popovic, Stanujkic & Karabasevic (2019) proposed the application of the hybrid model based on the SWARA and WS PLP methods in the case of selection of the appropriate hotel type for construction.

In this paper the evaluation and selection of the appropriate type of hotel for investing in is performed by using an approach based on Single-Valued Intuitionistic Fuzzy Numbers (SVIFN). Three decision-makers (hereinafter marked as *DMs*) assessed five types of hotels planned for the construction on the Golija mountain (Horwath HTL, 2007) in relation to the selected set of 5 criteria. We emphasize the fact that the main goal of the paper is to point out the advantages and applicability of the SVIFN in the process of estimation and selection of the optimal type of a hotel for investment. With that aim, the rest of the paper is organized as follows: Section 1 presents the Introduction; Section 2 presents the Preliminaries, Section 3 presents Numerical illustration and finally at the end of the manuscript Conclusions are given.

PRELIMINARIES

This section considers some basic concepts of Intuitionistic Fuzzy Set (IFS), Intuitionistic Fuzzy Numbers (IFNs) and linguistic variables.

Basic concepts of Intuitionistic Fuzzy Sets

IFS theory was introduced by **Error! Hyperlink reference not valid.** (1986). In addition to belonging to a set, proposed in Fuzzy Set (FS) theory, in IFS theory **Error! Hyperlink reference not valid.** also introduced not belonging to a set. Therefore, an IFS \tilde{A} in X can be defined as follows

$$\tilde{A} = \left\{ \langle x, \mu_A(x), \nu_A(x) \rangle \mid x \in X \right\}, \quad (1)$$

where: $\mu_A(x)$ and $\nu_A(x)$ denote the degree of membership and the degree of non-membership of the element x to the set A , respectively; $\mu_A : X \rightarrow [0, 1]$ and $\nu_A : X \rightarrow [0, 1]$; $0 \leq \mu_A(x) + \nu_A(x) \leq 1$.

In addition, a very useful parameter, called the degree of indeterminacy $\pi_A(x)$ of x to A , is defined in the IFSs theory, as follows

$$\pi_A(x) = 1 - \mu_A(x) - \nu_A(x), \quad (2)$$

under the following condition

$$\pi_A(x) \in [0, 1]. \quad (3)$$

Single-Valued Intuitionistic Fuzzy Numbers

As with the FS theory, the IFS theory also proposes several shapes of IFNs. The significant shapes are the triangular and trapezoidal ones when the linear membership functions are used, while with the bell-shaped ones the non-linear membership functions are preferred.

In addition to the above-mentioned shapes, the singleton shape can be pointed out as a characteristic one. A singleton IFN \tilde{A} , or Single-Valued Intuitionistic Fuzzy Number (IVIFN), $\tilde{A} = \langle a, a' \rangle$, is defined with the membership $\mu_A(x)$ and non-membership $\nu_A(x)$ function, respectively, as follows:

$$\mu(x) = \begin{cases} 1 & x = a, \\ 0 & \text{otherwise,} \end{cases} \quad (4)$$

$$\nu(x) = \begin{cases} 1 & x = a' \\ 0 & \text{otherwise,} \end{cases} \quad (5)$$

where: parameter a indicates the most promising value that describes belonging to a set, parameter a' indicates the most promising value that describes not-belonging to a set.

Basic operations on SVIFNs. The operations of addition and multiplication on IFSs were defined by Atanassov (1994). Let $\tilde{A} = \langle a, a' \rangle$ and $\tilde{B} = \langle b, b' \rangle$ be two SVIFNs. Then, the operations of addition and multiplication on SVIFNs are as follows:

$$\tilde{A} + \tilde{B} = \langle a + b - ab, a'b' \rangle, \quad (6)$$

$$\tilde{A} \cdot \tilde{B} = \langle ab, a' + b' - a'b' \rangle. \quad (7)$$

Score function of SVIFNs. Chen and Tan (1994) introduced a Score function to provide a method for comparing IFSs. Let $\tilde{A} = \langle a, a' \rangle$ be a SVIFN. Then, the score $S_{\tilde{A}}$ of \tilde{A} is as follows

$$S_{\tilde{A}} = a - a', \quad (8)$$

where $S_{\tilde{A}} \in [-1, 1]$.

As in the case of IFSs, the Score function can be used to rank the IFNs, as it is previously shown.

Ranking of SVIFNs. For two SVIFNs \tilde{A} and \tilde{B} , with scores S_A and S_B , the following condition applies:

$$\tilde{A} > \tilde{B} \quad \text{if} \quad S_A > S_B \quad (9)$$

Intuitionistic Weighted Arithmetic Mean of SVIFNs. Let $\tilde{A}_j = \langle a_j, a'_j \rangle$ be a collection of singletons SVIFNs. Then, the IWAM of singleton IFNs is as follows

$$IWAM(\tilde{A}_1, \tilde{A}_2, \dots, \tilde{A}_n) = \left(1 - \prod_{j=1}^n (1 - a_j)^{w_j}, \prod_{j=1}^n (a'_j)^{w_j} \right). \quad (10)$$

Intuitionistic Fuzzy Linguistic Variables

The linguistic variables have been extensively used in order to simplify the use of fuzzy numbers. In this approach a linguistic scale adopted from Stanujkic, Zavadskas, & Tamošaitienė (2015) is used. The linguistic scale is shown in Table 1.

Table 1: Linguistic variables for expressing satisfaction and dissatisfaction levels

Linguistic variable	The corresponding numerical values
Completely (C)	0.995
Very high (VH)	0.875
High (H)	0.750
Moderate high (MH)	0.625
Moderate (M)	0.500
Moderate low (ML)	0.375
Low (L)	0.250
Very Low (VL)	0.125
Insignificantly Little (IL)	0.005

NUMERICAL ILLUSTRATION

In this section, the usage of SVIFNs is demonstrated on a case of the most appropriate hotel type selection on the Golija mountain. A team of three experts (decision-makers) has been formed with the aim of carrying out an evaluation.

At the beginning of the evaluation, the team of experts have defined a set of evaluation criteria. In this case, the team of experts have selected the following criteria: Investment – IN (C_1); Number of units - NU (C_2); Total area – TA (C_3); Price per night – PN (C_4); and Events – EV (C_5). Proposed set of the evaluation criteria will be used to evaluate five types of hotels planned for the construction on the Golija mountain (Horwath HTL, 2007): Destination hotel – A_1 ; Condotel – A_2 ; B+B Pensions – A_3 ; City houses – A_4 ; and Chalets – A_5 .

After that, experts evaluated alternatives in relation to selected criteria. In doing so, experts express their level of satisfaction and level of dissatisfaction using the linguistic variables shown in Table 1, or the numbers from an interval $[0,1]$. The ratings obtained from three experts are shown in Tables 2, 3 and 4.

Table 2: The ratings obtained from the first of the three experts

Criteria	C_1		C_2		C_3		C_4		C_5	
	μ	ν	μ	ν	μ	ν	μ	ν	μ	ν
A_1	M	L	H	VL	H	VL	H	VL	M	IL
A_2	MH	ML	H	VL	VH	VL	H	L	MH	VL
A_3	M	VL	M	L	L	IL	M	VL	MH	L
A_4	M	VL	MH	ML	MH	IL	M	VL	M	IL
A_5	L	VL	H	L	L	H	H	L	M	VL

Table 3: The ratings obtained from the second of the three experts

Criteria	C_1		C_2		C_3		C_4		C_5	
	μ	ν	μ	ν	μ	ν	μ	ν	μ	ν
A_1	ML	L	M	VL	MH	IL	M	L	MH	IL
A_2	MH	IL	H	VL	H	L	H	IL	H	IL
A_3	ML	L	ML	VL	ML	L	ML	IL	ML	L
A_4	L	IL	MH	VL	H	IL	M	IL	L	IL
A_5	VL	IL	M	IL	MH	IL	MH	IL	L	IL

Table 4: The ratings obtained from the third of the three experts

Criteria	C_1		C_2		C_3		C_4		C_5	
	μ	ν	μ	ν	μ	ν	μ	ν	μ	ν
A_1	ML	VL	MH	IL	MH	L	MH	VL	MH	IL
A_2	M	L	VH	IL	VH	IL	M	VL	H	IL
A_3	M	IL	ML	VL	ML	IL	M	IL	M	IL
A_4	ML	IL	H	IL	H	IL	M	IL	ML	IL
A_5	L	IL	MH	L	MH	IL	MH	IL	ML	IL

In order to be evaluated further, the ratings from Tables 2, 3 and 4 are transformed into numerical values. After that, the group performance ratings are calculated using IWAM operator, i.e. using Eq. (10). During this calculation, it is assumed that all experts have the same significance, that is $1/K$, which is 0.333. The group performance ratings are shown in Table 5.

Table 5: The group performance ratings

Weights	0.25	0.21	0.18	0.20	0.15
Criteria	C ₁	C ₂	C ₃	C ₄	C ₅
Alternatives					
A ₁	<0.54, 0.00>	<0.66, 0.12>	<0.66, 0.00>	<0.68, 0.00>	<0.6, 0.00>
A ₂	<0.47, 0.00>	<0.66, 0.00>	<0.73, 0.00>	<0.57, 0.00>	<0.47, 0.00>
A ₃	<0.34, 0.00>	<0.58, 0.19>	<0.58, 0.00>	<0.54, 0.00>	<0.43, 0.00>
A ₄	<0.24, 0.00>	<0.42, 0.00>	<0.47, 0.00>	<0.42, 0.00>	<0.27, 0.00>
A ₅	<0.09, 0.00>	<0.36, 0.00>	<0.09, 0.00>	<0.36, 0.00>	<0.20, 0.00>

The criteria weights, shown in Table 5, were determined using PIPRECIA method (Stanujkic *et al.*, 2017).

On the basis of the data from Table 5, the overall performance ratings are also determined using Eq. (10). Then, using Eq. (8), the value of the Score function for each of the considered alternatives was determined.

The overall performance ratings, values of Score function, and ranking order of consideration websites are shown in Table 6.

Table 6: The ranking order of the analyzed websites obtained on the basis of Score function

Alternatives	IWAM	S_i	Rank
A ₁	<0.63, 0.00>	0.316	1
A ₂	<0.59, 0.00>	0.296	2
A ₃	<0.5, 0.00>	0.252	3
A ₄	<0.37, 0.00>	0.187	4
A ₅	<0.23, 0.00>	0.118	5

As it can be seen from Table 6, the alternative A₁ is the most appropriate one among the considered alternatives.

CONCLUSIONS

Hotel industry represents an important industry that is often a subject to change. However, what cannot be changed easily, and to a great extent affects the business operations of the hotel, is precisely the type of hotel. Thus, when investing, special attention is given to the selection of the type of hotel for construction. The selection of the suitable type of hotel is usually the result of many analyzes, calculations and market research.

The selection of the suitable type of hotel for construction is the topic that was not observed enough. Therefore, in this paper is proposed one approach for the evaluation and selection of the appropriate type of the hotel for investing based on Single-Valued Intuitionistic Fuzzy Numbers. The applicability of the proposed approach is demonstrated through conducted real case study of the selection of appropriate type of hotel on Golija Mountain.

Conducted numerical example (case study) has shown that proposed approach is adequate when it comes to the selection of type of hotel. Alternative A₁ - destination hotel is the most appropriate one among the considered alternatives for construction on the Golija Mountain in the present conditions. If it is necessary approach could be easily adjusted with additional criteria of sub-criteria if needed. Also, proposed approach can be successfully applied for

solving problems in other areas as well. Obtained results confirm that application of the appropriate MCDM based models will minimize possibility of making wrong decisions, especially when it comes to investing.

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